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ABSTRACT

Abstracts and abstractors' critiques of six research reports related to preservice teacher education and instruction are presented. Aspects addressed in the studies include: (1) teaching strategy analysis models in middle school science education courses; (2) concerns-based adoption model (CBAM): basis for an elementary science methods course; (3) comparison of preservice elementary teachers anxiety about teaching students to identify minerals and rocks and anxiety of students in geology courses about identification of minerals and rocks; (4) the sequence of learning cycle activities in high school chemistry; (5) the influence of repeatable testing on retention in mastery learning; and (6) the effectiveness of laboratory photomicrography for studying microbiology in Nigerian secondary schools. Included for each study are the purpose, rationale, research design and procedure, findings, and interpretations. Four responses to critiques are also contained in the document, two to studies in this issue and two to studies in an earlier issue. (TW)

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NOTES FROM THE EDITOR

This issue contains critiques of published research articles relating to preservice teacher education (three articles) and to instruction (three articles) as well as four responses to critiques. Two of these responses (Eniaiyeju, Brumby) are to critiques of articles published in earlier issues of ISE. The other two responses (Westerback, Gonzalez) relate to a critique published in this issue.

In the Teacher Education section, Tobin's article relates to the use of strategy analysis of lessons emphasizing process skill development. Malone's article is a report of research examining a science methods course developed around the Concerns Based Adoption Model. The third article, by Westerback and Gonzalez, looks at the effect of anxiety on student performance in the identification of rocks and minerals.

In the Instruction section, Abraham and Renner report on the use of the learning cycle in high school chemistry; Dunkelberger and Heikkinen discuss the efffect of mastery learning on some student variables; and Ali describes the effectiveness of three types of secondary school microbiology instruction for Nigerian students.

John Edwards, James Cook University - Australia, wishes to share the credit for his critique of an article by Larwenz and Welch, published in Volume 12, No. 2 of ISE. His co-authors were Rosemary Hart, Ian Jackson, and Ken Theodore.

Patricia E. Blosser
Editor

Stanley L. Helgeson
Associate Editor

PRESERVICE TEACHER EDUCATION

Tobin, Kenneth. "Teaching Strategy Analysis Models in Middle School Science Education Courses." Science Education, 69 (1): 69-82, 1985.

Descriptors--*Classroom Observation Techniques; Elementary School Teachers; Higher Education; Methods Courses; Middle Schools; *Models; *Preservice Teacher Education; *Science Education; *Science Instruction

Expanded abstract and analysis prepared especially for I.S.E. by David R. Stronck, California State University, Hayward.

Purpose

The purpose of this study was "to describe teaching strategy analysis procedures as implemented in a preservice science education course." Strategy analysis in teacher training begins with the observation and coding of classroom behaviors. The observer then reduces the data into summaries leading to meaningful feedback with recommendations for change.

This study focuses on observing preservice teachers presenting process skills in microteaching. Preservice teachers often receive only sample lessons in preparation for presenting process skills. Tobin hypothesizes that the preservice teachers will have a greater achievement in process skills when they both recognize the appropriate model of behavior and receive feedback on their performance.

In 1982 Tobin proposed a model for lessons with a process skill orientation. The model has four phases. The first phase "preparing the learner" includes strategies of motivating, revising, and familiarizing. The second phase "investigation planning" requires generating questions, controlling variables, and defining operationally. The third phase "data collecting" involves the processes of observing and measuring. Finally the fourth phase "data processing" includes data manipulation and interpretation.

Rationale

Since the 1960s science educators have emphasized the development of process skills in most curriculum projects. Nevertheless, students

in the middle and secondary grades continue to have difficulty in achieving such skills as controlling variables and interpreting data. Preservice teachers need training in utilizing strategies that promote overt student engagement in process skills. Yeany (1977, 1978) reported a significant change in the behavior of preservice science teachers when they used a model to analyze systematically their microlessons with the assistance of their instructor.

In this study, the observations were made on the following nine components of the data processing model: (1) recording data in a table, chart, diagram or sketch; (2) ordering or estimating data from an investigation; (3) condensing or grouping data from an investigation; (4) preparing the axes from a graph; (5) plotting or displaying data in graphical form; (6) translating data from a graphical to a verbal form; (7) expanding by using data to extrapolate or interpolate; (8) comparing data that have been collected; and (9) inferring from data that have been collected.

Tobin also referred to several studies as he organized a series of interactions that would probably provide for maximum achievement in the use of the model. The teacher should begin with a demonstration of the behavior described in an objective (Type B interactions). The teacher then interacts with the students by focusing their attention through questions, directions, and explanations (Type C interactions). Finally the students demonstrate and practice the behavior (Type A interactions).

Treatment 1 was the instruction given to a sample of 109 students. During a four-week interval, they received four lessons developed using a model described by Tobin and Capie (1980). Each lesson lasted for two hours and was suitable for use in middle school grades. In the fourth week, a summative achievement test to measure process skill achievement was taken.

Research Design and Procedure

Random assignment to treatment groups was not possible. To compare the formal reasoning ability of the two groups, the Test of Logical Thinking (Tobin & Capie, 1981) was administered at the Western Australian College.

Treatment 2 was the instruction given to a sample of 92 students. During a four-week interval, they had eight hours of instruction in strategy analysis activities designed to improve process skills teaching. These students completed the summative achievement test that was taken by the students in the first treatment.

The design of the study is the following:

$$q \quad x_1 \quad a_2$$

$$q \quad x_2 \quad a_2$$

where:

q is the Test of Logical Thinking

a_2 is a process skill achievement measure

x_1 is treatment 1, and

x_2 is treatment 2.

The study also reports data on the behavior of students attempting to use the strategy analysis procedures.

Findings

The mean achievement on the process skill test by the students in treatment group 2 (having strategy analysis) was more than a standard deviation above the mean for students in treatment group 1 (having model lessons). On the other hand, the average formal reasoning ability of students in treatment group 2 (measured by the Test of Logical Thinking) was less than that of the students in group 1. A test for the statistical significance of the difference in group means was not done because of the assumption that the large sample sizes and the large difference in scores would certainly provide statistical significance.

Seventy-eight students were randomly selected to provide evaluative data on the implementation of the strategy analysis procedures. Approximately 50% of their lesson time was allocated to student demonstrations of behavior (Type A interaction). Approximately 40% of the time was for attention focusing behaviors such as questioning, directing or explaining how to perform in an appropriate manner (Type C interaction). The amount of time allocated

for Type B interaction (teacher demonstration of behavior) was less than the suggested 20 to 25% of the time. According to Tobin, the preservice teachers probably felt less risk in involving responses from others than in modeling behaviors in the micro-teaching environment.

After suitable instruction, more than 50% of the preservice teachers did incorporate the series of interactions, beginning with the teacher demonstration of behavior. The preservice teachers most frequently had sustained overt engagement with the following components: naming and identifying variables that may affect a responding variable, and formulating a hypothesis.

The most obvious need for improving the program is better quality in the model tapes. Some of the preservice students had difficulty in regarding the micro-teaching lessons as significant to their future teaching of school pupils. A few of the preservice students resisted the use of a model that seemed complex and involved jargon.

Interpretations

Tobin concludes that the strategy analysis procedures are superior to the more conventional training (through model lessons) in providing preservice teachers with higher achievement levels on a test for process skills. The strategy analysis procedures helped preservice teachers to learn well the skills of appropriate strategies for teaching science processes. They conformed well to the model for phases related to preparing the learner, investigation planning, and data planning.

ABSTRACTOR'S ANALYSIS

Tobin does not use the term "inquiry" in his discussion of any model of teaching. He describes his model as having process skill or activity orientation. On the other hand, Bruce Joyce and Marsha Weil (1972), in their book Models of Teaching, do not give the title of "Process Skill" or "Activity Oriented" to any model of teaching. But they do describe the inquiry approach in several models, e.g., the

"Inquiry Training Model" of J. Richard Suchman, and the "Biological Science Inquiry Model" of Joseph Schwab. Tobin's terminology seems to require some analysis to relate his work to the matrix of other studies in the same area.

Probably there is little basic difference between Tobin's model of process skills and that inquiry model of Joseph Schwab. Both require the student to use the scientific processes to arrive at information. Tobin describes Type C interactions that include questions which focus attention on an objective. Schwab describes posing questions that will lead the student into interpreting data. Tobin's model is not a new set of ideas but simply a new way of expressing strategies advocated by most leading science educators.

Tobin observed that some of the students in this study complained about the jargon in his model. Readers of this article may also feel some distress in the complexity of the terminology. For example, Tobin seems to interchange arbitrarily the term "activity" with "process" in his title for a model. Later he divides his model into an "investigation model" and a "data processing model." He provides four tables to describe the use of his terms "phase, operation/strategy, type of interaction, operation, and component." Processes are re-organized into "operations" (that are major categories of processes, e.g., data manipulation) and "components" (that are specific processes, e.g., preparing the axes from a graph.) Although the details of his system are logical, the entire plan seems unnecessarily complicated for preparing teachers. The scientific method can be well understood and practiced without using most of the elaborate classification presented in this study. Tobin's study is directed at a major problem: training preservice teachers to present the scientific processes. Such presentations do involve the inquiry approach because the students are required to make scientific interpretations. Paul DeHart Hurd (1976) observed the depth of the problem:

> Although the new science courses made major contributions to curriculum theory, especially the elementary science programs, the reform movement was vetoed in the classroom. Courses were considered too difficult for most students; teachers did not

understand their conceptual structure and did not (or could not) master the inquiry or discovery style of teaching that was essential to the success of the new courses.

Most of the preservice teachers in this study did incorporate the desired teaching strategies. Bruce Joyce and others have observed that the most successful training systems include steps found in Tobin's program, i.e., clearly demonstrate the appropriate behavior, give time for practice, and provide feedback on that practice. Tobin's study is another example of implementing the best methods of instruction for preparing teachers.

A relatively small part of Tobin's paper is dedicated to describing a research study that is essentially a posttest-only control group experiment. The outcome of this research is that students had significantly higher achievement scores on a process skill achievement measure after being involved in the strategy analysis activities. These students had more time to practice investigation planning and data processing operations. The control group received more conventional lessons showing appropriate instruction with much emphasis on data collecting tasks. The higher scores on the process skill achievement test may simply indicate that the students involved in the strategy analysis activities had superior training on the nature of process skills. Tobin draws only a very limited and safe conclusion from these data: "There was also evidence to suggest that strategy analysis enhanced achievement levels above those obtained in conventional settings in an equivalent amount of time."

In general, there has been a shortage of studies in the area of science teacher education. Tobin's study is limited to microteaching in one university. The study could be continued by observing the behavior of preservice teachers instructing students in public schools and by observing the behavior of credentialed teachers in their classrooms. It is hoped that such additional studies will encourage the development of programs promoting the practice of processes and inquiry. The teaching strategy analysis models show great promise to help both preservice and inservice teachers.

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Descriptors-*Attitude Change; *Elementary School Science; Higher Education; *Methods Courses; *Preservice Teacher Education; Science Education; *Science Instruction; *Teacher Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Willis J. Horak, University of Arizona.

Purpose

This study evolved because of the identified problem of elementary teachers not fully utilizing the developed hands-on curricular programs even though these programs have been shown to be superior to non hands-on programs. The major purpose of the study was to assess the relative effectiveness of three different types of elementary science methods courses on improving attitudes and on advancing concerns about science teaching. It was designed to evaluate whether an elementary science methods course developed around a "Concerns Based Adoption Model" would have identifiable advantages over other types of courses. It additionally attempted to extend the implications of Concerns Theory to specific pre-service teacher education courses.

Rationale

The study was based upon Concerns Theory as developed by Hall, Wallace, and Dorsett (1973). This model emphasizes that people move through self concerns, to task concerns and lastly to impact concerns as they progress through their initial teaching experience. The studies cited indicated that presently most methods courses do not effectively deal with the actual concerns of students and in fact sequence instruction in a nearly inverse manner. Generally, topics on impact are introduced first, followed by task concerns, and finally be self concerns. It was conjectured that an elementary science methods course sequenced in a concerns based fashion would develop teachers

who were more amenable to using the curricula and materials that research has shown to be effective in the elementary schools.

Research Design and Procedures

The sample consisted of 85 students enrolled in undergraduate programs in elementary teacher education. The students were not truly randomly assigned to treatment groups. The fact that they were assigned by the student teaching office to 19 selected schools influenced the selection process. The treatments varied in sequencing and content of the course. Topics in the control group were sequenced in the usual manner. One experimental group had topics sequenced in a "Concerns" based manner a priori. The second experimental group had topics sequenced dynamically in response to their answers on a concerns questionnaire given at weeks one, five, and nine. The control group studied more topics dealing with historical and philosophical topics then did either of the experimental groups.

The criterion measures were the Stages of Concerns Questionnaire (Hall, George, and Rutherford, 1979) and the Science Teaching Attitudes Scales (Moore and Sutman, 1979). These tests were administered on the first day of class, on the second from last day of class, and after the student teaching experience. The pre-test scores were used as a covariate.

A 3x2x3 factorial design was employed to analyze the dependent variables. This consisted of three treatment groups, two age levels, and three levels of grade point average. Additionally, paired t-tests were utilized to test the pretest to post test gain scores for each treatment.

Findings

No significant differences were found with the analysis of covariance procedure. This was true for the concerns questionnaire and also for the attitude questionnaire. The paired t-tests indicated

that all treatment groups significantly changed over the duration of the experiment. All three methods classes were effective in increasing higher level concerns and in improving attitudes.

Intepretations

The non-significant findings may be the result of the short (one semester) time of the experimental treatment. Alternately, they may be the result of the make up of the criterion measure. The SoCQ is designed for in-service teachers and consequently many of the questions related to professional and administrative concerns. These questions may have been irrelevant for the pre-service teachers and thus influenced the overall homogeneity of the means.

ABSTRACTOR'S ANALYSIS

Overall this study was well designed and implemented. It is theory based and deals with a very relevant topic. The sequencing of instruction is always a concern of teacher educators. While instructors most often let the structure of the discipline determine the sequencing of their courses, this study attempted to let the professional concerns of the students determine the sequencing of the course. More studies need to be done that address this issue.

The fact that the students were not entirely randomly assigned to treatments causes some concerns. These concerns are somewhat addressed with the in-depth description explaining the exact procedures utilized for assignment to treatments. Another item of concern relates to the selected alpha level. It was chosen to be 0.10. Since this is not the usual procedure, one would expect to find some discussion of the fact. This is not done. Lastly, I would like to see an overall table of means and standard deviations for all the criterion measures. Such a table is of more importance than Figure 3 which is a graphic display of norm referenced scores for the diagnostic instrument.

One additional concern relates to the sequencing of the topics for the second experimental group. Even though they had higher norm referenced task concerns at week one, this group was still introduced to material related to self concerns. The author needed to address that issue. In fact, this group's self concerns were never as high as their task concerns and their impact concerns. Maybe this indicates that some of the topics selected for inclusion in the course were not relevant and thus should have been eliminated. As reported, the author chose to sequence the material in exactly the same sequence for both experimental groups. I feel an alternative would have been to develop more teacher education modules in science instruction that focused upon task concerns. This may have proven to be a more judicious use of the 14 weeks. In a sense, the control group deals with these concerns before the experimental groups deal with them. The reported class outlines indicate that the control group begins to address task concerns in the middle of the fourth week and that both the experimental groups must wait until the beginning of the sixth week. This may have influenced both groups making them both somewhat concerns based and somewhat non-concerns based.

The discussion section could have been expanded. The author does speculate on some possible reasons for the reported results. However, he cited the most obvious ones and did not do any in-depth analysis of the situation. One can always speculate that length of treatment was insufficient or that the utilized testing instruments were in actuality not valid. But there are probably other possibilities which further perusal of the raw data would reveal. The reader does not have this available and thus is at an extreme disadvantage on this task. The author is the one who knows best the idiosyncracies of the study and thus is in the best position to conjecture about it. I would also like to see some suggestions for follow-up research. One is left with the feeling that there are no implications of the study and thus it is of little consequence. I do not feel this is the case.

The research reported here adds to the body of research on pre-service teacher education. It supports the results of other

studies and also raises several generalization questions about Concerns Theory. It is thus significant, even though most of the statistical tests did not reveal differences among the treatment groups. Based upon studies such as this one it appears as if different topics probably should be identified and included in the elementary science methods courses.

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Descriptors--*Anxiety; *College Science; College Students; Elementary School Teachers; *Geology; Higher Education; *Preservice Teacher Education; Science Education; Science Teachers, Sex Differences

Expanded abstract and analysis prepared especially for I.S.E. by Gerald H. Krockover, Purdue University.

Purpose

The purpose of Westerback and Gonzalez's study was to "measure initial anxiety levels and anxiety levels after completion of grouping minerals and rocks tasks in two different student populations (preservice teachers and students in geology classes)" (p. 64).

Rationale

The rationale for this study was to, "investigate preservice elementary teachers and their anxiety about teaching students to identify minerals and rocks." The second part of the study was to investigate, "students taking geology as an elective to fulfill their science requirement and their anxiety about the identification of minerals and rocks" (p. 64).

Research Design and Procedure

For the first part of the study, preservice elementary teachers that were enrolled in Science 3, Science 1 (laboratory courses), or Science 15 (lecture course only) were utilized as the population sample. Students in Science 3 (earth science) met three times a week,

students in Science 1 (earth science/biology) met twice a week, and students in Science 15 (earth science/biology) met one evening a week for lecture. The lecture contact hours were identical for Science 3, Science 1, and Science 15. Teacher I taught the lecture for Science 3 (n = 19), and Teacher II taught the lectures for both Science 1 and Science 15 (n = 39). Teacher II taught the laboratory for all students.

Subjects were 58 preservice elementary teachers enrolled in one of the three science courses. Most (98%) of the students were female sophomores and juniors between the ages of 18-36. The average age was 20 years. Anxiety about teaching students to identify minerals and rocks was defined as measured by the State-Trait Anxiety Inventory Form Y-1 (STAI). The heading on the scales was changed from "Self-Evaluation Questionnaire" to "How Do You Feel About Teaching Students to Identify Minerals and Rocks?" for the A-Trait. The instrument itself was not altered. On the first day of class, prior to any instruction, students were asked to complete the STAI and a demographic questionnaire. Several weeks later a lab practical was given. After completion of the lab practical, students exchanged papers and corrected the exams. Opportunity was given to question each answer. After the students received and verified their grades, the second STAI was administered. Since there were two teachers, it was decided to determine first whether the results for their students were the same or different so that the decision could be made about combining the data. Analyses of variance were used and it was found that the overall difference between the State anxiety of students of the two teachers was not significant. The difference between the two testings was significant, indicating that, for the entire group, their State anxiety decreased from testing I to testing II. Since the students of Teacher I and II were not significantly different on either State or Trait anxiety, the effect of teacher was not considered for any additional analyses, and the data were combined.

Part 2 of the study involved 56 students in Geology 1 courses. Fifty-nine percent of the sample were male, 82% were freshmen and sophomores. The same instruments were used for this sample as for Part 1 of the study. However, the laboratory exam had ten samples of minerals and rocks instead of twenty. The ten samples were selected

from the twenty used with the preservice elementary teachers. The exam was shortened to make administration of the test and student feedback more comfortable during a regular lecture section. For both State and Trait anxiety, it was shown that there were no significant differences for teachers, testings, and their interaction. This indicated that for geology students, there was no change in State and Trait anxiety. Since the students of Teacher I and II were not significantly different on either State or Trait anxiety, the effects for teacher were not considered for any additional analyses, and the data were combined.

Findings

Examination of the means and standard deviations for Part 1 of the study indicated that this group of preservice elementary teachers had higher initial State anxiety levels than would be expected in college students. The preservice elementary teachers in this study were anxious about teaching students to identify minerals and rocks. State anxiety, which measured students' anxiety about teaching students to identify minerals and rocks, was changed in a positive direction for the group after completion of the identification task. Although the analysis of grade groups indicates that there was no relationship between grades and anxiety levels, it is possible that this effect was masked by the high achievement of the group. Nearly all students were academically successful and nearly all had significant State anxiety reduction. As expected, Trait anxiety remained unchanged in this study.

For Part 2 of the study, there was an overall difference between grade groups for State anxiety. Students in the higher grade group had lower anxiety and vice versa. These results indicate an adverse relationship between grades and State anxiety and agree with results found in other studies. There was no significant difference between the two testings. Interaction was significant and shows that the State anxiety was reduced from testing I to testing II for the above mean group but increased from testing I to testing II for the below mean group. Since most of the preservice elementary teachers were

female, there was no opportunity to examine the difference in anxiety levels between the sexes in both parts of the study.

For both State and Trait anxiety there was no significant effect for sex or testings. For Trait anxiety there was a significant interaction. This interaction showed that the Trait anxiety levels of the males increased from testing I to testing II while the Trait anxiety of the females decreased from testing I to testing II. In order to determine if the difference between the Trait anxiety could be accounted for by a difference in academic performance between males and females, a t-test was performed between the mean grades of males and females and found not significant.

Although no formal analysis was done to compare preservice elementary teachers and students in geology courses, the high initial State anxiety means of the perspective teachers indicate they were more anxious about the task of teaching students to identify minerals and rocks than geology students were about the identification of minerals and rocks.

Interpretations

Examination of State and Trait anxiety levels for the sample as a whole indicates there were no significant changes in these measures between testing I and testing II suggesting that the group was homogeneous. However, when the sample was split into two groups (above and below the mean laboratory examination grade), the analyses show the above mean group (lower anxiety) showed a decrease in anxiety from testing I to testing II. Likewise, students in the below mean group (higher anxiety) showed elevated scores from testing I to testing II. This indicates the sample was not homogeneous. There were no significant overall differences in STAI scores of male and female students for State or Trait anxiety and no differences in scores for the two testings. The interaction for State anxiety was not significant. However, for Trait anxiety scores of the males were slightly elevated and the females slightly reduced. This significant difference cannot be explained by the slightly higher achievement of females in this study.

The results of these studies indicate that anxiety about a specific task, the characteristics for identification of minerals and rocks, appears to be reduced by successful completion of that task. In this study two different groups of students were examined and, in both cases, anxiety reduction took place. There were no significant anxiety differences between male and female students taking geology courses dealing with characteristics for identifying minerals and rocks. This does not support the contention that females may be more anxious about science than are males. The data from geology students support the concept that a relationship exists between achievement as measured by grade and anxiety levels. Students with high achievement on a task appear to have lower anxiety and vice versa.

ABSTRACTOR'S ANALYSIS

It probably would have been helpful to the reader if this study had been separated into what it really is--two studies. The first study dealt with preservice elementary teachers and their anxiety regarding their ability to identify minerals and rocks. The second study dealt with students enrolled in a geology course (non-elementary teaching majors) and their anxiety with respect to their ability to identify minerals and rocks. Unfortunately because this two part study was combined into a single article, confusion reigns.

Other concerns include that preservice elementary teachers were enrolled in one of three courses. Although the course numbers differ, the content for the initial period of instruction, during which the study was conducted, was identical for all courses. With two teachers involved in the teaching of the course, one teacher involved in the laboratory for the course, and three different courses, variables are extremely confounded. Furthermore, the courses with the preservice elementary teachers were 98% female, whole courses with the geology students were 59% male. Other concerns include the changing of heading on the scales for the STAI examination. Furthermore, it is not clear how long a period elapsed between the pre and post testing. The authors simply state that, several weeks later, a lab practical was given. Is two weeks sufficient for a study that deals with

student levels of anxiety? Furthermore, the authors indicated that students exchanged papers and corrected the exams. Is this a suitable way to evaluate an examination that is being used to verify concerns regarding anxiety levels? In addition, the methods used to combine data from two different teachers is questionable.

Another questionable feature of this study is the fact that the lab exam for the elementary teachers included twenty mineral and rock samples, while the lab exam for the geology students included only ten samples of minerals and rocks. If I was enrolled in a course and knew that my laboratory examination would have twice as many minerals and rocks as students enrolled in another course that is supposed to be similar, I would have increased anxiety simply based upon that difference. The authors also point out that the exam was shortened in response to the test administration procedure and to make the student feedback more comfortable during a regular lecture session. One has to wonder that if the desire of the authors is to make students more comfortable, would that not result in decreased levels of anxiety?

Since this study is fraught with errors that would be of great concern to science educators and educational researchers, one must be concerned with respect to the results obtained. While the conclusion stated by the authors indicates that anxiety can be successfully reduced, these conclusions cannot be directly traced to this study. Other studies that have been conducted with respect to anxiety levels have taken a much more cautious approach and based their research upon data that have been collected under controlled conditions. The mixing of populations, the use of a variety of courses, the use of several teachers, the changing of titles for a standardized assessment instrument, and the conduct of a study over a several week period result in conclusions that cannot be viewed as having a substantial level of credibility. In the future it is hoped that other researchers take these concerns into account when investigating anxiety among teaching and non-teaching majors via the science curriculum.

INSTRUCTION

Abraham, M. R. and J. W. Renner. "The Sequence of Learning Cycle Activities in High School Chemistry." Journal of Research in Science Teaching, 23: 121-143, 1986.

Descriptors--*Academic Achievement; *Chemistry; *Cognitive Processes; High Schools; *Learning Processes; Piagetian Theory; Science Education; *Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by J. D. Herron.

Purpose

"The sequence of the three phases of two high school learning cycles in chemistry was altered to: (1) give insights into factors which account for the success of the learning cycle, (2) serve as an indirect test of the association between Piaget's theory and the learning cycle, and (3) to compare the learning cycle with traditional instruction." (Abraham and Renner, 1986, p. 121)

Rationale

The learning cycle was formulated during the development of the Science Curriculum Improvement Study (SCIS) as an attempt to apply Piaget's theory of intellectual development to science instruction. As originally formulated, the learning cycle begins with an exploration phase in which the student engages in laboratory observation or other appropriate activity that confronts the student with some relationship or concept concerning the natural world. This activity takes place before the concept or relationship is formally named or discussed and serves to establish a need to know, to stimulate curiosity, raise questions, or otherwise set the stage for more formal treatment of the concept, principle, or relationship that is the focus of instruction. In the second phase of the cycle, the language, mathematical relationships, or other formalism normally used to rationalize the phenomena experienced during the exploration phase is introduced. This is normally achieved through class discussion directed by the teacher. Karplus described this second phase as

invention. Finally, the meaning of the new idea is clarified, consolidated, and extended through a variety of activities that may include additional laboratory work, reading, or homework assignments. This final stage was originally referred to as discovery.

Abraham and Renner point out that the sequence of instructional activities described by the learning cycle differs from normal, expository instruction where new concepts are generally named and defined at the beginning of the instructional sequence. This introduction of concepts or principles may then be followed by laboratory work or reading assignments designed to present evidence in support of the concept or principle introduced, and students are then assigned various exercises in which they practice using the concept or principle in a variety of contexts. The major distinction between the two approaches is that in the learning cycle, students encounter the phenomena before being introduced to the language that has developed to describe the phenomena.

As Abraham and Renner point out, the sequence of activities described by the learning cycle appears to be more compatible with the processes of assimilation and accommodation that Piaget and other developmental psychologists argue are at the heart of all learning. If this is true, then altering the sequence in which the three learning cycle phases are presented to students should have an effect on their learning and attitude toward the material presented. It is this hypothesis that is examined in the study.

Research Design and Procedure

The study was conducted in six high school chemistry classes taught by two teachers in a single school. A number of tests (Otis-Lennon Mental Abilities Tests, the Group Embedded Figures Test, and the chemical combinations and flexible rods tests developed by Wylam and Shayer) were administered to all students, and student age and overall grade-point average in chemistry were collected and compared. The results of these comparisons indicated that there were no differences between the classes taught by the two teachers. In addition, there were no differences among the various classes at the beginning of the school year, but the Piagetian test given at the end

of the year indicated that class 21 had a higher score on the Piagetian test than did class 25, and class 21 contained a greater proportion of formal operation students than did class 25. This difference in classes was compensated for in the statistical analysis.

The treatment consisted of teaching two previously developed learning cycles to each of the six classes but varying the sequence in which the three phases of the cycle were presented. The sequence was randomly assigned to the six classes. The first of the two learning cycles dealt with physical and chemical change and was the second learning cycle encountered by students in the course. The other learning cycle manipulated during the study dealt with thermodynamics and was taught near the end of the school year. Although not explicitly stated in the article describing this research, the learning cycle was presumably used as an instructional device throughout the school year in all classes, and all learning cycles other than the two mentioned were presented in the normal sequence of exploration, invention, and discovery [or as Abraham and Renner describe the phases, data gathering (G), conceptual invention (I), and expansion (E)].

Although there are six permutations of the learning cycle phases, the authors point out that this is somewhat misleading. There is little difference between the instructional activities associated with the data gathering and the expansion phases. What makes them different is whether the activity precedes or follows the conceptual invention phase. As a result, the variable actually manipulated is the placement of the conceptual invention phase at the beginning, middle, or end of the sequence.

The authors describe four kinds of data that were collected to assess the effect of varying the sequence of activities in the learning cycle: class observations, case studies based on individual interviews of a few students, achievement tests administered at various stages of the instruction, and an inventory of student attitudes concerning each of the learning cycles. Virtually all of the discussion in this article was based on an analysis of the achievement test results.

The design of the study is perhaps best described as a counterbalanced design, but it does not fit any of the designs discussed by Campbell and Stanley (1963) exactly. Alternate forms of the content achievement test (CAT) were administered before the

learning cycle began (CAT 1) and after each phase of the cycle (CAT 2, CAT 3, and CAT 4). For the second learning cycle manipulated during the study, a retention test (CAT 5) was administered three weeks after instruction ended. Analysis of variance was then used to see if there were differences in means that could be attributed to differences in the students' developmental level (concrete or formal) or to the placement of the invention phase at the beginning, middle, or end of the learning cycle. Keep in mind that the study manipulated the sequence of the learning cycle phases so when CAT 2 was administered, some classes had just completed the invention phase (I), others had just completed the data gathering phase (G), and others had just completed the expansion phase (E). Similarly, when CAT 3 was administered, all classes had completed two of the three phases, but one had completed IE, another IG, another EI, another GI, and still others EG and GE. The important point is that two classes had completed the invention phase at the beginning, two had completed it second, and two had not completed that phase. When CAT 4 was administered, all classes had completed all phases of the cycle, but in different orders.

Discussion of results was primarily in terms of the trends observed in the CAT scores when the invention phase occurred first, second, or last in the cycle. That trend was discussed separately for students classified as concrete operational and those classified as formal operational.

Findings

The authors found that, although the sequence of the three phases of the learning cycle is important, no one sequence is best in all circumstances. Physical and chemical change was apparently a review for most students whereas the concepts in the learning cycle on thermodynamics were apparently new. The authors suggest that this may account for the different results obtained for the two parts of the study.

For the learning cycle involving chemical and physical change, it was found that concrete students who received the invention phase last scored higher on the posttest (CAT 4) than did concrete students who received the invention phase either first or second. However, for

formal operational students, there seemed to be some advantage in having the invention phase occur either first or second in the sequence. Regardless of sequence, the formal operational students scored higher on all of the CATs than did the concrete operational students.

For the learning cycle involving thermodynamics, it was found that achievement was greater when the invention phase comes between the data gathering and expansion phases. This was true for both concrete operational and formal operational students. This, of course, is the normal sequence for the learning cycle.

Interpretations

The authors conclude that it is the placement of the invention phase of the learning cycle that really matters. However, whether the ideal placement is the customary position seems to depend on whether the concept being taught is new to students or a review, or whether the students operate at the concrete operational level or are comfortable with formal operations. For new concepts, the customary position of the invention phase (i.e., between the data gathering phase and the expansion phase) appears to be best. However, if the concept is actually a review, placing the invention phase first seems to work best for formal operational students whereas placing it last seems to be best for concrete operational students.

The authors suggest that the placement of the invention phase first in instruction dealing with review concepts may work well for formal operational students because the exploratory or data gathering phase has effectively taken place in previous instruction.

ABSTRACTOR'S ANALYSIS

Research in science education has made significant strides in the past twenty years. There appear to be fewer one-shot studies in which someone gets a bright idea and attempts to test that idea with a superficial study that has weak theoretical underpinnings and no follow-up. Although such studies are occasionally interesting, they don't have much lasting impact on instruction. In contrast to such

atheoretical work, John Renner and his associates at Oklahoma have conducted a long series of studies based on Piaget's theory of intellectual development. Those studies have contributed much to our understanding of how Piaget's ideas can be translated into educational practice. The present study is no exception.

Since Karplus and his associates developed the idea of the learning cycle as part of their work on the Science Curriculum Improvement Study, many science educators have advocated the use of learning cycles in science instruction, but there has been no careful examination of the strategy to see when it works and why. This study helps fill that void.

There are clearly many factors that influence the success of instruction: the nature of the learners, the nature of the material to be learned, and the nature of the instruction itself. These variables always interact in complex ways that make it difficult, if not impossible, to describe the optimum instructional practice under all circumstances. The best we can hope for is sufficient understanding of how these variables operate to make informed judgments.

The learning cycle is based on a particular theoretical understanding of how learning takes place and, to some extent, this study is a test of that theory. In broad strokes, this theory states that knowledge is constructed in the mind of the learner. What mental structure a learner develops is influenced by the stimuli coming from the external environment through the learners' senses, but it is not the case that information is transmitted, intact, from the external world to the head of the learner. The stimuli are transformed as they are incorporated, and the nature of that transformation depends on the beliefs, attitudes, existing knowledge, and intellectual habits of the learner. It is the interaction between the existing cognitive structure of the learner and the incoming stimuli -- a process that Piaget describes as assimilation and accommodation -- that determines what is learned.

The learning cycle describes three phases of instruction that should facilitate learning; first, by providing stimuli that produce a disequilibrium or discontinuity between one's existing cognitive structure and the information contained in the stimuli; second, by presenting (or assisting the learner in inventing) ideas that seem

capable of resolving the disequilibrium; and third, assimilating the new idea to the overall cognitive structure by extending the use of the new idea to new phenomena and connecting it to other ideas held by the learner.

The view of learning on which the learning cycle is based holds that disequilibrium; i.e., some discontinuity between the ideas to be learned and the ideas already held, is a necessary condition for meaningful learning. Thus, the learning cycle begins with an exploratory (or in Abraham and Renner's terminology, a data gathering) phase designed to create some measure of disequilibrium. During this phase the learner encounters events that cannot be totally rationalized in terms of what is already understood. It serves to "establish a need to know" on the part of the learner. It causes the learner to realize that something is going on "out there" in the world of experience that cannot be satisfactorily explained "in here" in the world of thought.

Abraham and Renner contend that normal instruction is inconsistent with this understanding of the learning process in that it fails to begin by establishing disequilibrium. Rather, it begins by presenting the learner with new concepts that others find useful for rationalizing experience, and it does so before there is any disequilibrium within the cognitive structure that needs to be resolved. Consequently, the theory would argue, instruction is less effective, Abraham and Renner's results seem to support this argument -- at least in the case of new concepts such as the thermodynamics in the second learning cycle manipulated in the study. Thus, this study seems to support the theory of learning on which the learning cycle is based.

But there is a problem. The theory of learning appears to be sound, and the learning cycle seems to describe phases of instruction that are compatible with that theory, but it is far too simplistic to suggest, as some have, that we should mold all instruction into a series of learning cycles. First, there is the evidence from this study that in some cases it may be preferable to omit the exploration phase and begin with the invention phase where the concepts commonly used to rationalize experience are presented first. Second, there is the evidence that an order that is best for some students (e. g., those who use formal operations reasoning) is not ideal for others.

Students do not come to us as blank slates. They have already had experiences, many of which have produced unresolved disequilibrium or which have resulted in accommodations that we describe as "misconceptions" because they produce rationalizations of experience that differ from the norm. How do we optimize the instructional sequence under these conditions?

We have no definitive answer to the question we raise, but it seems clear that we have entered the realm in which the classroom teacher must exercise judgment based on a sound understanding of the learning process rather than on the basis of slavish adherance to a pattern or template for instruction such as the learning cycle. The important issue, it would seem, is whether a need to know has been established and whether the student has a cognitive structure to which the new concepts can be assimilated. Does some disequilibrium exist or must it be created? Has the student developed operational knowledge that enables the student to infer relationships that will either create or resolve disequilibrium, or does the student make sense of the world using logical tools that are powerless to reveal these relationships? Almost certainly, the optimum instructional sequence depends on the answers to such questions, and there is equal certainty that in the typical classroom the answers differ for different students.

Perhaps the most that can be said at the present time is that the three phases of the normal learning cycle are compatible with our understanding of how learning takes place. When we are teaching material that is likely to be new to the majority of our students, we are on solid ground if we organize instruction around the learning cycle or some other pattern that serves the same function (i.e., begin by exposing the student to events that are not totally explainable in terms of existing cognitive structure and thus establish a need to construct new ideas that are capable of rationalizing those events, next assist the student in the construction of those new ideas by "inventing" the concepts or relationships that others have used to make sense of thse events, and finally assist the student in internalizing the new learning and relating it to other ideas through use of the idea in a variety of contexts). We should also be alert to the fact that, for many ideas that we teach, students come to us

ready to assimilate the concepts that we have to present because they have already had experiences that they are unable to rationalize and are already trying to resolve some disequilibrium that has resulted from those experiences. That being the case, a data gathering or exploratory phase may be unnecessary and we may be better advised to begin instruction by making verbal ties to that prior experience and move quickly into the invention phase of instruction. There will be judgment calls, and as with any judgment call, we will undoubtedly err, assuming that the stage has been set for the invention phase when it has not. This was apparently the case for the concrete operational students in the learning cycle on chemical and physical changes during this study. In that event, we must be ready to retrace our steps, reset the stage, and return to the invention phase of the lesson after the student sees the potential value of the idea in rationalizing experience.

It may seem to the reader that this analysis of the study under review has little to do with the study. It neither addresses questions or methodology nor considers the validity of the results. Still, I believe it is the right analysis, for this study attempts to do what all research in science education should be doing. It begins with a clearly defined theoretical framework and it provides information that allows us to examine the implications of that theory for instruction. I hope that my analysis clarifies just what those implications may be.

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Descriptors-*Academic Achievement; Educational Research; Grade 9; *Mastery Learning; *Science Instruction; Secondary Education; *Secondary School Science; *Student Attitudes; *Testing

Expanded abstract and analysis prepared especially for I.S.E. by Elizabeth Kean, University of Wisconsin-Madison.

Purpose

Mastery learning, as proposed by Bloom, has the following components: the use of diagnostic quizzes to assess attainment of behavioral objectives, remedial instruction for students who failed to reach pre-determined mastery levels of the objectives, and subsequent retesting to ensure that mastery had been attained through remediation. In this study, the authors assessed the effect of the repeated testing component of the mastery learning model on the retention of science content, attitudes toward science study, completion of optional activities, and the achievement-aptitude correlation.

Rationale

The authors cited seven studies which report the success of mastery learning. Two additional works were cited as supporting the retesting aspect of mastery learning as producing significant affective and cognitive gains over use of mastery learning without retesting. One doctoral thesis cited found no difference in performance of mastery learning students with or without retesting. Given these conflicting results, this study investigated further the effect of retesting as a component of mastery learning. The group with retesting was labeled as the "external monitor" group; the group without retesting was the "internal monitor" group. The extent to which these labels imply motivation for students (external vs internal) was not discussed.

The authors were working within a framework which accepts mastery learning as a viable method of teaching in science classes. They were not examining mastery learning per se, but a specific feature of the mastery learning theory. There was an assumption that the design of the experiment was capable of keeping all facets of instruction identical, except for the one variable which was being tested (repeatable vs nonrepeatable testing), and that any differences between groups would be due to this specific factor.

Research Design and Procedure

Design. The study followed a pretest/post-test control group design. The internal monitor group was the experimental group. The external monitor group, required to retest to the 80% criterion level, was the control group. Students were 9th graders, in an introductory physical science course (ICP). Total pool of students was 273, which constituted the upper 85% of students in a specific high school. Students were described as "typically upper middle class suburban youths," slightly above average on state-administered verbal aptitude tests. Students were randomly assigned into 14 class sections. Five of these sections were randomly selected and assigned to the control group and five others to the experimental group. Students were tested on four measures. Only students who had scores on all four measures were included in the study. Cell sizes were equalized (by random removal of students from the group in excess) to 56 students. All data were reported for total students in each group, irrespective of section assignments.

Treatment. Students in the external monitor group were required to perform at the 80% criterion level on computer generated achievement tests at unspecified points in the modules before being allowed to proceed through the ICP program. The internal monitoring students used computer generated nonrepeatable tests to identify problem areas which needed to be fully restudied before continuing. All students studied five modules in the ICP course for the full academic year and the differential treatment was continued through the

entire year. Both groups used the ICP text which included objective-referenced learning activities that students could use for remedial learning and had identical grading procedures (the initial test results for each group determined the grade, irrespective of retesting opportunities). The number of teachers in the study was not reported, but each instructor taught equal numbers of class sections in each treatment. The study "focused" on the 15 weeks during the second and third of the five ICP instructional modules. Content and topics of these modules were not described.

Instrumentation. A 45 item cognitive achievement test was developed by the researchers. Items assessed student attainment of 33 of the 45 cognitive objectives in the two ICP modules studied. To verify content validity of the items, a panel of judges (unidentified) successfully matched items with the appropriate objectives. Students completed this test as part of their June final exam. KR-20 reliability was .89.

Attitudes toward science were assessed by using a 16 item adaptation of the Heikkinen Student Opinion Survey in Chemistry, in which the word "chemistry" was replaced by the word "science." Equal numbers of positive and negative statements (in random order) were included in the scale. Reliability (coefficient alpha .94), validity (method of assessing) and scoring procedures (assignment of values to responses) were discussed. The attitude survey was given as a pretest in September and, with items randomly rearranged, as a posttest in January after completion of the two modules being studied.

Verbal aptitude was assessed by scores on the Delaware Educational Assessment Program Verbal Aptitude Test. Reliability was given and claims for validation of an ETS test (from which this test was adapted) were included. The authors did not specify when this test was given.

Student use of free-time optional course related activities were recorded in six categories. Means and standard deviations for each type of activity for each group were tabulated.

Findings

Neither student achievement, science attitude, or the achievement-aptitude correlation was affected by repeatable testing. ANCOVA techniques revealed no significant differences in student achievement scores when verbal aptitude was taken into consideration. Achievement-aptitude correlations of .62 (internal monitor group) and .61 (external) did not differ significantly. Differences in the mean number of times students in each group engaged in optional learning activities for each of the six categories were significant, with externally monitored students participating more. The groups also differed in the amount of time spent in optional course related activities. ANOVA techniques compared the free time spent by students in the ICP area for purposes other than testing (e.g., requesting help, studying). Significant differences ($p < .05$) were found in all categories in favor of the external monitor group.

Interpretations

The authors interpret their results to mean that repeatable testing by itself does not contribute significantly to student achievement or attitudes. The only difference found between experimental and control groups was in the extent to which students in the retestable group were motivated to complete optional learning activities. The fact that the retests did not affect grades did not seem to affect motivation to engage in such activities.

The authors stated that these results imply that perhaps it was the remediation itself, rather than the retesting provision, which was responsible for the cognitive gains which are seen with mastery learning. If this is true, then retesting, which is logistically difficult in many school situations, may perhaps be omitted, increasing the appeal of mastery learning. They further noted that these results do not support "single-time testing" without remediation as a substitute for full re-testing provisions of the conventional mastery learning model. Students in this study seemed to be able to

carry out internally monitored remedial activity to meet course learning objectives. The authors suggested that future work might be devoted to development and refinement of additional diagnostic and remedial materials for student use, keyed to regularly-administered tests.

ABSTRACTOR'S ANALYSIS

The nature of the "treatments." The authors attempted to show that the treatments for each group were different in some educationally significant way. Both groups took a test after some sort of undefined learning activities. (To understand the nature of the ICP course, the reader must seek additional information outside the article.) Based on the results of that test, students learned what required objectives still needed to be mastered. No information was given about what learning activities took place in the classroom that related to a completed test. It was stated in the article that mastery learning has a remedial component after testing, which students in both groups presumably accomplished. But what was the nature of this work? Was the remediation powerful enough that simply completing the remedial activities led to complete learning? If this was so, the issue of retesting was moot. If students completed the remedial materials and received feedback from the activities or teacher that they have mastered the objectives, it would be irrelevant to their learning whether or not they went on to actually demonstrate to themselves on a formal test that the material had been mastered.

It would have helped to have data on the timing of student remedial activities and retesting. How many times did students need to retest in order to achieve mastery? How much time did students spend on the remedial materials? How did students learn what they had and had not mastered as they worked through the remedial materials? What were the directions to the student about what actions they needed to engage in after the test? The reader is given no information about these questions.

Although students' grades have already been determined on the basis of the original test, retestable students still had to invest time and energy in the retests. They were not permitted to continue with the module unless they demonstrated their mastery of the objectives at the 80% criterion level. Did the teachers in the study hold to this? Did all students actually meet the criterion for all objectives?

Purpose of the optional activities. Because their course was modularized, students had free time in which they could choose to engage in remedial activities. Both groups indeed did this, although to differing extents. What was the nature of these activities that students performed? The article listed six categories (requesting help, working in lab, working on mini-labs, taking tests, studying, other reasons), but no discussion about what these activities were or how they related to computer generated tests on module objectives.

It would have been interesting if the authors had asked the students why they engaged in these kinds of activities. What was the purpose of these activities? Did students in either group engage in activities because the activities were inherently interesting? What part did the fear of failing the retest and not being permitted to go on with the module play in the use of these activities? Retestable students had to face another test: Did they engage in optional activities in the blind hope that more work (of whatever kind) would enable them to pass the course? In retrospect, did students waste their time in engaging in these activities since there was neither affective or cognitive gains associated with them? Were the cognitive/affective effects of these materials not capable of being measured by the instruments in the study? Were the activities "overkill," i.e., activities which repeated information that students had already mastered in the remedial part of the program? What time did students actually spend on these activities? How did this time compare with the time spent on remedial materials?

Important educational issues. Hidden in this work are some important educational issues. How do students know when they have studied enough? When faced with alternative learning activities,

how does a student select from among the alternatives? What instructional patterns and materials foster self-monitoring of learning? Obviously, no one small study can answer these questions. But such questions can be explored as the authors explore the nature of specific learning theory.

The effect of creating labels for educational activities/processes carries with it a danger that the labels mask more than they reveal. For example, repeatable testing is given as a required component of mastery learning. But what is accomplished by the repeatable test? Is the real issue here the feedback which students receive about the status of their learning after remediation? If this is true, then the feedback issue rather than the testing issue is what can be explored in future work. The authors indicate that development of additional diagnostic and remedial materials might be as effective as remedial testing in generating such feedback.

Content of the article. The authors described their sample and their instruments in a satisfactory way. As noted above, more description on the nature of the instruction (regular classroom and remedial) as well as the optional learning activities would have been helpful. It is not clear whether class activities in the control and experimental groups were identical. No information was reported on the amount of time students in either group spent learning science in class, during free time, or outside of school. Statistics for reporting of data were adequate.

Table 2 could have been more explicit. It is unclear what means are being reported in that table. Are the number of times, rather than some time unit that students worked on activities in the optional categories, being reported in that table?

Ali, Anthony. "The Effectiveness of Laboratory Photomicrography for Studying Microbiology in Nigerian Secondary Schools." Journal of Research in Science Teaching, 21(1): 63-70.

Descriptors-*Academic Achievement; Instructional Materials; *Microbiology; *Photography; Science Education; *Science Instruction; Secondary Education; *Secondary School Science; Student Motivation; Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by April L. Gardner, University of Northern Colorado.

Purpose

The purpose of the study described in this paper was to evaluate the effectiveness of three types of secondary school microbiology instruction in Nigeria: lecture only, lecture plus laboratory, and lecture plus laboratory supplemented by photomicrography. The three types of instruction were evaluated in terms of student achievement, student motivation, teaching time required, usefulness as instructional aids, and cost-effectiveness. Ali hypothesized that supplementing laboratory instruction with photomicrography would result in the most positive outcomes in all of the above areas.

Rationale

No references were cited in the paper, which included a short introduction describing the current state of microbiology instruction in Nigeria. Ali noted that microbiology in Nigerian secondary schools is taught using lectures only, although the West African Examinations Council had mandated that laboratory work using microscopes be used for instruction. No previous research on the use of photomicrography as an adjunct to laboratory work was discussed.

Research Design and Procedure

Participants in the study were 720 fourth year secondary school microbiology students (equivalent to 11th grade in the United States)

from schools in each of Nigeria's states. One school from each of the 12 states and 60 students from each school were randomly selected to participate. Three teachers from each school were involved in the project. The 36 participating teachers completed a 30-hour science teaching skill development program prior to teaching the microbiology classes. They received training with laboratory equipment and photomicrography, in addition to discussions of class management, student evaluation, philosophy of science education, and other aspects of science education. The teachers' science process teaching style was determined using the Shrigley-Johnson Science Attitudes Test and teachers were divided into a "high-process oriented" group and a "low-process oriented" group. Equal numbers of high and low process-oriented teachers were assigned to teach in half of the schools. Ali did not describe how teachers were assigned to the three treatment groups within each school. The abstractor suggests the pattern depicted in Figure 1 as a logical possibility.

Figure 1
Assignment of Teachers to School and
Treatment Group, by Teaching Style*

	School											
Treatment	1	2	3	4	5	6	7	8	9	10	11	12
Group 1	H	H	L	L	L	H	H	H	L	L	L	H
Group 2	L	H	H	L	H	L	L	H	H	L	H	L
Control	H	L	H	H	L	L	H	L	H	H	L	L

*H = high process orientation; L = low process orientation
The design possibility assumes equal numbers of teachers with high and low process orientation. Ali did not report the number of teachers characterized by the two instructional styles.

A posttest only, control group design was used. The 60 students in each school were randomly assigned to either a "lecture plus laboratory and photomicrography" group, a "lecture plus laboratory" group, or a "lecture-only" group. These groups were called Group 1, Group 2, and Control Group, respectively. All students completed the same 10 units of microbiology in five 45-minute periods per week for 12 weeks; each of the 36 groups had a different teacher. The teachers for the Control Group led lectures while students copied notes from the blackboard. Students in Group 2 prepared slides and performed experiments with microorganisms in addition to listening to teachers' lectures. Students in the lecture plus laboratory and photomicrography group also participated in laboratory experiments and heard lectures but, in addition, photographed slides of each prepared specimen using an instant print camera mounted on the eyepiece of the microscope.

At the end of the course, teachers completed a questionnaire to assess their perception of the usefulness and practicality of the mode of instruction used. Students answered a questionnaire (which was also called a student attitude questionnaire) designed to determine various aspects of the course, including motivation toward the mode of instruction, perception of materials completed, and perception of teacher's effect toward the instructional mode. In addition, students were posttested on content knowledge using the 1971 West African School Certificate Examination questions in microbiology, which included 20 multiple-choice items in microbiology "theory" and three essay questions on microbiological laboratory methods.

Data analysis consisted of a comparison of Group 1, Group 2, and Control Group responses on the questionnaires and on the achievement test. Analysis of variance was used to determine whether students' achievement test scores varied significantly and Tukey's HSD test was used to determine significant subsets of scores.

Questionnaire responses were analyzed by comparison of percentages of students or teachers responding in a particular manner. There was no indication that any statistical test (e.g., a chi-square test) was used to determine whether significant differences on

responses existed among the three treatment groups. Ali stated that a "motivation index" for each group of students was calculated by dividing the mean achievement test scores by the percentage score on the questionnaire. The motivation indices were reported, but the necessary data for calculating them was not. Finally, the total "actual teaching time" for each group was determined by a research assistant at each school who observed classes. This time was reported as 45 hours for each of the three treatment groups.

Findings

Analysis of variance of posttest scores on the achievement test revealed a significant difference in mean treatment group scores ($F = 17.24$; $p < 0.05$). Tukey's test indicated that each group's mean score differed significantly from the other groups' scores. Table 1 reports the mean achievement test scores. Highest scores were obtained by the group of students who participated in the laboratory

Table 1
Mean Achievement Test Scores

Treatment*	Mean Score
Group 1	83.80
Group 2	74.02
Control Group	62.90

*Group 1 = lecture, laboratory, photomicrography
Group 2 = lecture, laboratory
Control Group = lecture only

with photomicrography in addition to lecture, followed by the group of students who completed laboratory and lecture. The lowest tests scores were achieved by students taught by the lecture-only method.

Responses on teacher questionnaires indicated that 90% of the teachers using lecture and laboratory with photomicrography found that instructional mode useful; 87% found it a practical instructional strategy. Eighty-three percent of the teachers using lecture and laboratory found this instructional mode both useful and practical. In contrast, 67% of teachers using the lecture-only teaching style felt that strategy was useful and 45% felt it was practical. No other teacher responses were reported.

Students' perceptions of the motivating effect of the three instructional modes were determined using the motivation index defined previously. Ali reported that Group 1 students had the highest index, followed by Group 2 students, which was followed by the Control Group students. No statistical tests for significant differences among the three indices were reported.

Actual teaching time was reported as 45 hours for each of the three treatment groups. Ali reported the cost per pupil for materials and equipment which he purchased for the study. This expense did not include the cost of materials and equipment which belonged to the schools. Cost per pupil (U.S. dollars) was $8.00 for the photomicrography group, $5.00 for the laboratory group, and $1.50 for the lecture-only group.

Interpretations

The author concluded that the educational gains made by microbiology students who received the lecture, laboratory, and photomicrography mode of instruction made the additional cost of this instruction worthwhile. He indicated his belief that using photomicrography as an adjunct to the laboratory is the most appropriate and effective mode for teaching microbiology.

ABSTRACTOR'S ANALYSIS

The paper reviewed here describes an interesting study of the effects of instructional method on students' learning of microbiology

content. Unfortunately, the report has several omissions which limit the possibility of replicating the study under conditions which could extend the generalizability of the results.

No published work was referenced, nor was any rationale given for the addition of photomicrography to the laboratory. It appeared that the study was based entirely on the author's personal beliefs and/or experiences. Had any previous work using photomicrography as an adjunct to laboratory suggested improved learning among students? Was it expected that improved learning would occur as the result of increased interest among students due to the novelty of the experience, or the result of seeing increased detail in specimens, or the result of having an improved study aid (the micrographs) for tests? The study as reported was "research in a vacuum." This is unforgivable, given the current amount of research on the effects of "discovery vs. expository" instruction, "inquiry-oriented" teaching, and "experiential" learning. Numerous studies are summarized annually in Science Education. Olstad and Haury (1984) noted several articles published in 1982 which reported the effectiveness (or lack of effectiveness) of laboratory experience on student learning of science concepts. A consideration of research on the effects of laboratory experiences on learning would not only have related this study to the body of research in this area, but may also have suggested further questions to pursue in this study.

Information about the procedures and measures used was generally lacking. Ali described the teacher-training seminar adequately and stated that teachers were characterized as "high process-oriented" or "low process-oriented" based on their responses on the Shrigley-Johnson Science Attitude Test. The attitude test was not referenced, nor was any description of the categorization process given. (For example, were teachers above a median score considered high process-oriented and those below that score considered low process-oriented?) Shrigley and Johnson (1974) reported the development of a Shrigley-Johnson Science Attitude Scale, a Likert-type instrument to measure science attitudes of in-service elementary teachers. It would seem to be an inappropriate instrument

for the measurement of secondary school science teachers' instructional preferences, if this was the instrument Ali used. Furthermore, the process orientation of teachers was not mentioned in the results. Did high process-oriented teachers express a more favorable attitude to using laboratory with photomicrography than did low process-oriented teachers? That kind of information could be very useful for determining the likelihood that teachers will actually use photomicrography if it is available to them, an important factor in the ultimate cost-effectiveness of the novel technique.

It was not clear how teachers were assigned to the three treatment groups within each school. Figure 1 presents one alternative which seemed logical to the abstractor, although teachers may have been assigned on a completely random basis (except that each half of the schools had equal numbers of high and low process-oriented teachers).

Ali's definition of "actual teaching time" was also unclear. He indicated that it did not include time needed for laboratory preparation or clean-up. The actual teaching time for each group was reported as 45 hours, so apparently the term meant "in-class time" (5 days/week x 0.75 hours/day x 12 weeks). Apparently Ali wished to confirm that laboratory and laboratory plus photomicrography did not require more in-class time than did lecture-only. He noted that all teachers were given laboratory preparation time, whether or not they utilized laboratory instruction. While this time was available to all teachers, those who did not need it for laboratory preparation could have used it for grading, making lesson plans, or other chores associated with teaching. The extra time required for laboratory preparation, rather than in-class time, may be the more important time requirement to determine, because it may be a factor which determines whether laboratory or laboratory plus photomicrography is actually utilized by teachers. Some discussion of how adequately the three instructional modes were implemented in the classrooms, as reported by the observers, should also have been reported.

Ali described the development and testing of the teacher and student questionnaires (they were administered to other teachers and students and revised based on the original responses), but did not

provide sample questions or indicate whether responses were made on a Likert-type scale, or as written short answers, or in some other manner. The most serious problem with the two surveys was that it appeared that both teachers and students were asked to compare their instructional mode with two modes which they had not experienced.

Table IV in the report (p. 69) indicated that teachers' perception of the usefulness and practicality of the instructional mode used were two aspects of the teacher survey; it is not clear whether those were two specific items or a number of items which made up two subscales. Items for the student questionnaire were similarly obscure. Each treatment groups' perception of the motivating effect of their instructional mode was determined by a motivation index, obtained by dividing the mean posttest score by the percentage score on the student questionnaire. The precise meaning of "percentage score on the student questionnaire" was unclear; it appeared to be the percentage of students in each instructional group who felt their mode of instruction was "the most motivational teaching-learning mode" (p. 69). Ali stated "Eighty-seven percent of group 3 [control group] students perceived lectures as boring and nonmotivational teaching-learning mode for the study of microbiology since motivation index expressed by group 3 students was 0.13 ...," (p. 69). Apparently the motivation index was interpreted as the percentage of students in each treatment group who found their instructional mode interesting and motivational. No rationale for this interpretation was given. In addition, the motivation index for the Control Group was given as 0.13 in the text and 0.21 in Table IV (p. 69).

Student learning of microbiology content was assessed by a standardized achievement test used in West Africa. Twenty multiple-choice items comprised a "theory" portion of the examination and three essay items comprised a portion of the examination on microbiological techniques. While evaluation of the objective part of the test seemed straightforward, the process used to evaluate the essay part was not described, nor was the relative weighting of the two parts of the test explained. If both portions of the test were weighted equally, it may not be surprising that students who

participated in laboratory techniques (Groups 1 and 2) scored significantly higher on the achievement test than did those who did not have laboratory experience (Control Group).

All teachers were given training in laboratory and photomicrographic techniques, but one-third of them (Control Group teachers) were not allowed to use these techniques and another third (Group 2 teachers) were not allowed to use photomicrography. It seems likely that many teachers were frustrated that they could not utilize instructional modes to increase student learning and may have communicated this expectation to their students. This possibility jeopardizes the conclusions drawn from the study.

A different design which required no more effort on the part of the investigator would have circumvented this problem and could have yielded more information about the effectiveness of the three instructional modes. Since all participating teachers received training in laboratory and photomicrography techniques and ten microbiology units were covered during the 12-week study, teachers could have used the lecture-only, lecture plus laboratory, and lecture plus laboratory supplemented by photomicrography modes of instruction each for three units (with one unit, perhaps the introductory unit, left out of the study). A sample design for one of the schools using this procedure is shown in Figure 2. Other schools could use the three instructional modes in different orders.

Figure 2

Sample Design for One School,

Using All Three Instructional Modes with All Classes*

	Unit								
Teacher	1	2	3	4	5	6	7	8	9
1	C	C	C	I	I	I	II	II	II
2	I	I	I	II	II	II	C	C	C
3	II	II	II	C	C	C	I	I	I

*C = lecture only; I = lecture, laboratory; II = lecture, laboratory, photomicrography

Using this design, teachers and students could justifiably compare the three instructional modes and the effectiveness of the three methods in the hands of all high and low process-oriented teachers could be compared. Furthermore, some conclusions about the usefulness of laboratory and laboratory supplemented by photomicrography for teaching the various topics within microbiology could have been made. This result would contribute to the determination of the cost-effectiveness of the three instructional modes. For example, if laboratory plus photomicrography resulted in greater student learning of topics in units 5, 6, and 8, but not in the remaining units, photomicrography could be utilized only during the appropriate units, reducing the overall cost of supplies needed for the entire course.

On the positive side, this study included a large sample size and cross-section of Nigerian schools. The results of the study indicate that the "lecture-only" method is unsatisfactory for microbiology instruction. The fact that students who received the innovative instructional method scored significantly higher than the other students on the achievement test combined with the fact that a large majority of teachers who utilized this technique found it useful and practical indicated that the effectiveness of using laboratory supplemented by photomicrography should be explored further. A replication of the study without the omissions noted here (or a more complete report of this study) would contribute to a more complete understanding of student learning in science.

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RESPONSE TO ANALYSIS

IN RESPONSE TO THE ANALYSIS OF

Eniaiyeju, Paul A. "The Comparative Effects of Teacher-Demonstration and Self-Paced Instruction on Concept Acquisition and Problem Solving Skills of College Level Chemistry Students" by Carolyn Carter, David V. Frank, and April Gardner. Investigations in Science Education 12 (3): 3-10, 1986.

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Author's Response to Abstractor's Analysis

The following comments are made in the order in which the issues are raised in the abstractor's analysis and critique.

Reliability

On page 3 of the critique, a question is raised about the reliability and the validity of the 16-item Likert scale given at the end of eight sessions to measure students' attitudes toward the two instructional methods.

The issue of the validity and reliability of the attitude scale was taken care of during the validation of the instruments used in the pilot and main study. The panel of experts described in the article under 'instruments' was engaged for this purpose. Basic to the validity of the attitude scale are the right questions phrased in the least ambiguous way. Do items sample a significant aspect of the purpose of the investigation? Do the respondents all have the benefit of real life qualifying situations? The panel of judges and the author were satisfied that these aspects have been adequately taken care of in the design of the study.

Reliability of the attitude scale was inferred from the second administration of the questionnaire to the subjects of the main study. A comparison of their responses with those obtained during the pilot study showed no contradictions. On the issue of a reliability coefficient, the author knew that the 16-item Likert scale was not a psychological test. A reliability coefficient could have been

calculated if there is a basis for belief that the four positions indicated on the attitude scale are equally spaced.

Scoring System

On page 4 of the critique, the scoring system used to derive an 84-point total for a 54-question test was queried. The system was not described because it is obvious in Table I of the article that the problem solving items of the test are rated one point higher than concept learning items. They are so rated because the skills required for problem solving are more difficult than those needed for concept learning.

On the same page, the abstractors asked if the results of the adjusted chi-square analysis are statistically significant. The abstractors left out the phrase "in favor of the self-paced mode of instruction" and claimed that the author did not indicate what the results of the adjusted chi-square analysis mean. The decision about the percentage of items that received positive responses is based on a significant chi-square value obtained for such items.

The corresponding table showing critical values of the chi-square analyses was dropped in compliance with the suggestion of one of the referees of the Journal of Research in Science Teaching (JRST).

The abstractors are not clear on page 5 of their analysis if students in the main study were asked to complete the Likert scale. Yes, they were. There is indication to this effect on page 799 of the article. See paragraph preceding 'Results'. "In the following academic session, the main study was carried out following the procedures of the pilot study." However, I agree with the abstractors that a statistical statement similar to that of the pilot study should have been made about the results of the Likert scale for the main group. The omission is regretted but it must have occurred in the process of complying with the suggestion to eliminate the table on adjusted chi-square values as mentioned earlier.

Still on page 5, the abstractors observed that no reference point is given under "discussion" where the author attempts to explain why

the teacher-demonstration method lowered the students' achievement. No reference point is given because the results of the investigation (pp 799-801) for both the pilot and main studies showed that subjects of the self-paced group in either study performed significantly better than those of the teacher-demonstration group. There is no confusion here since the results in both the main and pilot studies are not contradictory.

Self-Paced

On page 6 of the critique, the abstractors are not clear about exactly what Eniaiyeju means by 'self-paced'. What is meant by self-paced is clearly explained on page 797 of the reviewed article. This is under 'instruments' "... the worksheets in the package were written with a view of giving students the chance to carry out structured laboratory activities which would have been demonstrated by a teacher." And in the second to the last paragraph of the same page it is stated that "since the worksheets contained explicit printed guides, the responsibility for learning was placed on the student. How rapidly he progressed was left essentially to the student. The possibilities of any one individual attaining competence were enhanced since the environment in which he could progress was undiluted by frustration of moving ahead with bright students or the discouragement of waiting for the less bright students." This was the implementation of the self-paced concept of the study.

Gender Issue

One of the author's stated purposes is studying the interaction of instructional mode and gender. It was the view of one of the JRST referees that males and females should not be compared unless one can provide a strong rationale. Since there was no special reason for the comparison, the question and the analysis concerning the interaction issue were suggested for omission. Incidentally, the question on gender was inadvertently retained while the corresponding analysis was

omitted. The last chance of avoiding that mistake was lost when the galleys of the article failed to reach the author due to strayed mail and change in contact address.

Best Answer

The best answer to the test item on page 6 of the abstractor's analysis is (A) because:

(B) Hard water is not necessarily good for irrigation. The concentration of the minerals in the water must be known for the sake of good growth of the crops being irrigated.

(C) Not all chlorides, sulphides, and bicarbonates cause hardness. The conjunction 'and' should not be ignored.

(D) Only temporarily hard water gives a precipitate on boiling.

(E) Hard water is not necessarily sharp to taste. For this to be right the constituent of a specific sample of hard water must be named.

On the second item on page 7 of the abstractors' analysis, the critics admit that the author's distractors are plausible. This is one of the good qualities of a multiple choice item. This is hardly debatable. I disagree with the abstractors' choice of alternative (distractor) A as the best answer. The actual setting under which learning is taking place is provided by the instructional package being used by the students or the teacher in the study. Given this background:

(A) pour the extra oxalate back into the stock bottle is not recommended. The chances are high that the excess salt might contaminate the stock in the bottle.

(B) Flush it down the sink is not recommended because it is wasteful.

(C) Save it for later use is not recommended because the excess salt may be contaminated before later use.

(D) Adjust her experimental need to 15g is not the best answer because of quantitative considerations. Other

stoichio-metric changes may need to be made in terms of other reagents used in the experiment. The student may be ignorant of the appropriate changes.

(E) Ask her teacher where to dispose of it is the best answer.

Problem Solving or Concept Learning

The abstractors, on pages 8-9 of their analysis, questioned Eniaiyeju's classification of his test items. The author cited Campbell and Milne (1972) as his frame of reference. It is conceivable that knowledge will have grown over a period of 10 years which is the time between when Campbell and Milne published their book and Hayes (1981), Novak and Gowin (1984) published theirs. Campbell and Milne's ideas on the classification of abilities were current at the onset (1974) of Eniaiyeju's study. And even as of today there is no contradiction in the two sets of ideas (Novak et al vs Campbell and Milne) when numerical problems are considered in the sciences. Eniaiyeju's other test items (not included in the reviewed article) drew heavily on numerical problems in chemistry.

Teacher Effects

The role of the self-paced group teachers appears to have been misunderstood by the abstractors as revealed on page 9 of their analysis. The teacher for this group could not have constituted a confounding variable when evaluating test scores. His role was just to provide materials (reagents and chemicals) for the structured laboratory activities to be done by the students. The teacher also provided students with cards containing answers to the self-checking exercises which the self-paced subjects often came across. The teacher was more of an adviser than an instructor. His advice to abnormally slow students on the need to work faster is devoid of instruction on the contents of the units.

And even if it is accepted that the advice of the teacher cannot be separated from the effects of the mode of instruction, the fact

still remains that the self-paced group teacher is playing a comparatively negligible role in the learning process. A method such as this (which reduces the burden of work on the teacher and yet guarantees success on the part of the student) is an asset where competent teachers are scarce.

Insight

Finally, on pp 9-10 of the Critique, Eniaiyeju's study is said to "add another vote in favour of individualized instruction, without adding any insight into why this mode of instruction is sometimes successful." Certainly, such an insight will be useful. I dropped a hint on this on page 800 of the reviewed article: success under SP was most likely a consequence of greater degree of personal involvement leading to better and greater depth of understanding in the learning process. To say more than this will require a new set of data. And why individualized instruction is sometimes more successful than conventional methods is, strictly speaking, not part of the research questions.

IN RESPONSE TO THE ANALYSIS OF

Brumby, Margaret N. "Misconceptions About the Concept of Natural Selection by Medical Biology Students" by Richard Tolman. Investigations in Science Education 13 (2): 27-34, 1987.

Margaret N. Brumby

The abstractor has generally identified the key findings in the paper. I would like to respond to some points discussed in the Research Design section.

Several references [in 6(d) and (e)] imply that the research could be "improved" if it were made more generalizable, with random sampling etc., and with precise statistics rather than "qualitative" terms in the narrative. It seems it is still necessary to point out that the case study approach to exploring conceptual understanding is not psychometric research using small numbers. The aim of the research in this paper (and in other papers in this field) is to find out about the range of ideas and understandings associated with a particular concept, any or all of which a real teacher may find in a real student in a real classroom. We seek to find the range of their ideas, not of hypothetical "mean" students, or of statistical "mean" ideas. So generalizations to "all" such comparable students are not a goal. However, it is still useful to be able to say whether a particular finding (e.g., Darwinian explanations) is a frequent or very rare finding in the group under study.

This report does not set out to measure pre-and post-instruction as implied in 6(e).

The paper clearly set out that the group of students comprised the entire first year intake of a medical faculty for the written set of problems, and a sub-set of these who were interviewed. The original group (n=150) is not a random sample of secondary school leavers - no university intake could be considered this, and certainly no medical faculty intake. So a sub-set of a non-random sample, even if it were chosen randomly, would not then become a random sample. Students volunteered for interviews (more volunteered than I could cope with, so it was finally a first-come, first-served basis). The

question of volunteers is tricky - what sort of students would volunteer, and why? I was not a member of the medical faculty staff, so there would be no "brownie points" for participation. Indeed, I guaranteed confidentiality and that their explanations would not go to their faculty! Were they the cleverest students? Possibly, but look at the results! If this were indeed so, then these findings have very profound implications, for they mean that our most able school biological science students have failed almost completely to grasp one of the most central concepts of modern biology. Worse still, they have "learnt" 19th Century ideas! It seems that these volunteers were willing students who were interested in a set of problems which had made them think. Forced choice answers, such as in closed questionnaires and multiple choice questions, are not acclaimed in this regard. Students frequently describe how they have to "twist their understanding" to find an alternative which "most closely matches" their understanding, in such questions.

The other point deserving comment is contained in 6(h), re., ex post facto responses. It is true that written answers may be described in this way. But in the interviews, students were asked a series of probing questions: would they like to comment further on their own answers (which they re-read), what concepts they thought the questions were based on, and then asked to "think aloud" on several further problems. To listen to a student trying to answer a "why" question is exactly what the abstractor seems to be asking for - but it was the whole focus of the interviews! One of the most significant questions was the one set in the future (predict children's skin at birth); prediction questions, by their nature, require application of ideas, for there can be no rote-memorized "facts."

Taping students' interviews, transcribing verbatim and analyzing their own words and phrases is more laborious than forced choice answers, but what rich data! I know of no better method to find out the students "real" thinking (i.e., the concepts they use). But this is not the only advantage. The problems designed for the project can be used directly in the classroom, and can facilitate discussion of different explanations for a particular question. Research reports such as this may begin to bridge the gap between researcher and teacher, who may not have had time to find out where their students are in their conceptional development in science.

IN RESPONSE TO THE ANALYSIS OF

Westerback, Mary E. and Clemencia Gonzalez. "Comparison of Preservice Elementary Teachers' Anxiety About Teaching Students to Identify Minerals and Rocks and Students in Geology Courses Anxiety About Identification of Minerals and Rocks" by Gerald H. Krockover. Investigations in Science Education 13 (3): 15-20, 1987.

Mary E. Westerback
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I appreciate the opportunity to respond to the abstractor's comments and hope the additional information provided will clarify the use of the Science (or Science Teaching) State-Trait Anxiety Inventory in Science Education.

I have read the abstractor's comments carefully. There are a number of points of misunderstanding and disagreement.

A third author was not mentioned by the abstractor, namely Louis H. Primavera, Chairman of the Department of Psychology, St. John's University, Jamaica, New York 11439. He has a distinguished reputation in psychometrics. He is a recognized expert in data analyses and was consulted on the data section.

The abstractor is correct that there are two separate descriptive studies. They were reported in the same article, rather than two different articles, because the task (recognition of criteria for identification of minerals and rocks) was identical and it made sense to see if patterns of anxiety reduction were similar. The reviewer stated that this was confusing. The National Association for Research in Science Teaching awarded this paper the 1984 Outstanding Paper for Practical Application in the Classroom.

Only part of the purpose and rationale was stated by the abstractor. The investigation of anxiety levels of the two groups was based on the mastery of a specific task, namely the identification of criteria for identification of minerals and rocks. These observable

criteria were provided to both groups during the laboratory experience and the examination, thus eliminating any need for memorization.

It is appropriate to change the headings on the scales, but the scale should be (and now has been) renamed (Westerback and Primavera, 1987).

Changing the heading creates a situation where subjects elicit or tap into anxiety about a specific situation and using the same items allows the authors to take advantage of a well standardized test.

The State-Trait Anxiety Inventory has two scales. State anxiety is a transitory emotional state which can be influenced by training, while trait anxiety refers to relatively stable individual differences in anxiety proneness (Spielberger, et. al, 1983). The directions for the administration of these scales is critical because that sets the conditions for the individual's perception of the situation as threatening or not threatening. The directions were not included in the reviewed article, but have been previously reported in other studies by the author. Hindsight indicates that the directions should have been repeated here.

The headings for the state scale were different for the two groups. Preservice teachers were asked to respond to "How Do You Feel About Teaching Students to Identify Minerals and Rocks?" and students taking geology as a science requirement were asked to respond to: "How Do You Feel About Identifying Minerals and Rocks?" The heading on the State-Trait Anxiety Inventory have been modified for a number of studies, always with Dr. Charles Spielberger's permission and advice.

The headings, which were designed to correspond to specific situations which may evoke anxiety, were clearly indicated.

Other researchers are conducting studies using this modification. It is now important to "name" the adaptation. Westerback and Primavera (1987) now refer to this modification as the SCIENCE TEACHING STATE-TRAIT ANXIETY INVENTORY or the SCIENCE STATE-TRAIT ANXIETY INVENTORY, depending on the usage.

In response to the abstractor's "other concerns":

A. The different course numbers was a local institutional matter, which did not affect content. The abstractor agrees that even though the course numbers were different, the

instruction in the course segment used in the study was identical. What is the objection to combining data for these groups?

B. Teacher was not a variable in these studies. This was demonstrated by split-plot analyses of variance. Differences between the teachers was not a significant factor. Therefore, combining data from different teachers, teaching the same content to the same group of students is valid.

C. The preservice elementary teachers are predominately female and the geology courses contain both males and females. Because there are mostly females (98%) in the elementary education courses, it is impossible to do any analyses by sex. The geology courses allowed one to look at sex as a variable.

D. The time period for testing did allow sufficient time for instruction. There was laboratory instruction on minerals; sedimentary, igneous and metamorphic rocks; plus time for comparison and review. It is a misinterpretation to translate several weeks (4-5) to mean two weeks.

E. The exchange and correction of papers was an important part of the instruction. Students exchanged papers a number of times so that the individuals doing the correcting were never in view of their own papers. The "corrector" signed the paper on the bottom, used a red pencil to mark, and the papers were checked by the instructor later. The purpose of the correction during class was for students to see why the criterion they selected was appropriate or not based on the actual specimen. If the papers were corrected by the instructors and handed back next time, then the opportunity would be lost for questions and immediate feedback using rocks and mineral specimens.

F. This is not an experimental design. These are descriptive studies looking at what happened in the classroom when two different groups of students were performing the same task. The groups have different future expectations (teaching and non-teaching). The elementary teachers and the students

taking a required geology course were responding to different situations as indicated by the State-Trait measures, are in different programs, in different "schools" within the university, and generally do not discuss course or laboratory experiences.

The abstractor says he would be anxious if he had twice as many specimens as someone else. Our experience is that more specimens mean each specimen "counts" less. One would expect more specimens to reduce, not invoke anxiety. At our institution it is unlikely that this was a topic of conversation among the students. The number of specimens in the exam was not emphasized, but the use of criteria was. Students who are comfortable with and understand the observable characteristics and have this information provided in the exam are successful regardless of the number of specimens. The number of specimens really is irrelevant -- if you can do 10, you can do 20, or even 100. We discovered that it is just more practical to use 10 specimens.

G. Anyone with the appropriate experience in teaching geology could repeat this experience provided the individual or individuals:

1. Take care in the administration of the State-Trait Anxiety Inventory. Make sure the directions are clear and that administration is done in an environment where rapport is established so that participants can respond honestly.
2. Teach so that the criteria (which are neither absolute nor all encompassing but are selected for identification of characteristics of minerals and rocks) are clearly understood. Actually naming or identifying the specimens is not the goal. Identifying distinguishing characteristics (using information provided and not rote memorization) in unambiguous specimens is the goal. Many common rocks and minerals can be categorized in this way. What is important for students to learn is that the observable characteristics reflect the origin of the rocks. For

example, if large crystals are observed, the crystallization took place slowly, the rock was formed deep within the earth (took time), and under this system is a crystalline, coarse grained, igneous rock. If the rock is light in color, that observation is also noted. Naming the rock granite is not required and no extra points were given for the name.

3. The laboratory exam must contain specimens which are consistent with the expectations generated by the criteria, and consistent with concepts taught in lecture.
4. Administer the STAI after students have completed the task, know their grade, and understand why the criteria selected were correct or incorrect.

H. What other studies have been conducted with a more cautious approach? Please give citations.

I. The reviewer wonders if the desire of the authors to make students more comfortable would result in decreased anxiety levels. It is unclear what is meant by this.

Westerback and Gonzalez taught these classes in the same manner that all other classes have been taught before and since this study. We are both tenured, experienced teachers. We stated our expectations clearly and provided sufficient time for instruction, and provided testing material consistent with students' expectations. We reported all the conditions of teaching and testing.

In summary, the abstractor missed two fundamental points, namely the adaptation of a standardized instrument for measurement of anxiety, and the idea that anxiety about a specific task can apparently be reduced by successful completion of that task.

It is hoped that other researchers will continue to investigate anxiety about science and science teaching and share this information. The SCIENCE TEACHING STATE-TRAIT ANXIETY INVENTORY AND THE SCIENCE STATE-TRAIT ANXIETY INVENTORY provides a useful standardized assessment instrument.

What is needed in science education are studies conducted by different researchers with different groups (i.e. preservice teachers, inservice teachers and students in all grade levels and disciplines), with large enough sample sizes to provide norms for these groups. This is just beginning to happen.

At the American Educational Research Association national meeting, Washington, D. C., April 1987, a symposium on "Identifying Science Anxiety: Research and Curriculum Implications" was given. Participants were Leigh Chairelott, Bowling Green State University; Charlene Czerniak, Bowling Green City Schools; George Davis, Emporia State University; Joseph Goldsmith, University of Maryland; Madeleine Long and Mary Westerback, Long Island University; with Charles D. Spielberger, University of South Florida; and Frank Farley, University of Wisconsin (Madison) as discussants.

REFERENCES

Spielberger, Charles D., R. L. Gorsuch, R. Lushene, P. R. Vagg and G. A. Jacobs. Manual for the State-Trait Anxiety Inventory. Palo Alto: CA, Consulting Psychologist Press, Inc., 1983.

Westerback, Mary E. and Louis H. Primavera. (in press) "Anxiety About Science and Science Teaching" in Advances in Personality Assessment, Volume VII edited by Charles D. Spielberger and James N. Butcher, Hillsdale: NJ: Lawrence Erlbaum Associates, Inc.

IN RESPONSE TO THE ANALYSIS OF

Westerback, Mary E. and Clemencia Gonzalez. "Comparison of Preservice Elementary Teachers' Anxiety About Teaching Students to Identify Minerals and Rocks and Students in Geology Courses Anxiety About Identification of Minerals and Rocks" by Gerald H. Krockover. Investigations in Science Education 13 (3): 15-20, 1987.

Clemencia Gonzalez
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I concur with Westerback's response and would like to add to it.

Charles D. Spielberger (1985) has written a concise summary of research on the nature and assessment of anxiety over the past two decades.

A summary of research on science and science teaching can be found in Westerback and Primavera's (in press) invited chapter on anxiety about science and science teaching.

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Spielberger, Charles D. "Assessment of State and Trait Anxiety: Conceptual and Methodological Issues." The Southern Psychologist, 2: 6-16, 1985.

Westerback, Mary E. and Louis H. Primavera. "Anxiety About Science and Science Teaching," in Advances in Personality Assessment, Vol. VII, Charles D. Spielberger and James N. Butcher, eds. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. (in press)